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Transient Dynamic Analysis for Optimization of Tie Rod Using FEM

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Abstract- Today's world is competitive. The necessity of market demand for the advanced technology is in lower price. It reflects in making the technology cheaper. Hence, every organization striving for cost effective product at a lower price and within minimum period of time to market. That keeps pressure on engineers to consistently strive to design the most effective products at, the lower price. The work is focus on functioning of the tie rod, the methods of its performance evaluation its optimization. The tie rod end job is to ensure the wheels are well aligned. It provides the adjustment of wheel alignment that keeps the inner and outer edges of the tires from wearing out. Hence, the tie rod functioning is crucial for steering as well as suspension performance of vehicle. Hollow Tie rod with 11.0mm ID is select after analysis, and further material analysis is done using 11.0 mm as ID. It gives 13.80% less weight than solid tie rod, without failure. Aluminum is suggested as applicable material after analysis.

Index Terms- Tie Rod, Weight optimization, Transient Dynamic Analysis.

I. Introduction

Tie rod gets force applied from a rack, and further it transfer to the steering knuckle to turn the wheels. Tie rod failure might cause instability of vehicle, and that may result in a cause of an accident. So, it's important to observe the strength of tie rod before implementation into a vehicle. The load coming from steering to tie rod is mostly compressive. The efforts required where the car is moving are comparatively less with a stationary car. The working strength of the tie rod is that of the product of the allowable working stress and the minimum cross-sectional area. Rods are often made thicker at the end section; this means that the tie rod doesn't become weaker when the threads are cut into it. Tie rods are connected at the ends in various ways. But it is desirable that the strength of the connection should not be less than the strength of the rod. The threaded ends passed through drilled holes or shackles (it is a U-shaped piece of metal which is secured with a pin or bolt across the opening), and retained by nuts which are screwed on the ends over threaded section of the rod end. If the ends are threaded right hand and left hand, the length between the points of loading may be altered. A worn tie rod can cause wandering, erratic steering and also major tire wear and damage to the steering system. If a tie rod is present in such condition, a wheel alignment will also be required because alignment setting will get disturbed due to tie rod replacement. As the ratio of tie rod length to the radius of gyration of its cross section is on the higher side, it would likely buckle under the action of compressive forces. The will cause the wheel to turn as per given rotation (clockwise or anticlockwise). The outer tie rod end connects with an arrangement of adjusting sleeve, which allows the change in length of the tie rod i.e., it becomes adjustable. This adjustment is used to set a vehicle's alignment angle as per requirement. Failure of tie rod may occur due to unsuited loading (Hard steering like conditions), improper material selection, poor design, fatigue load and wear of tie rod. The indications of failure of tie rod are very less so it can be risky to have a circular rod with a threaded part, the outer end, and the inner end. The tie rod is mostly made up of material - alloy steel. A car's steering wheel is connected to the steering gear that helps the steering wheel turn the wheels. The steering gear is connected to the wheels via the tie rod ends. The job of the tie rod end is to ensure the wheels are aligned. It provides the adjustment for wheel alignment that keeps the tires from wearing out at the inner and outer edges. If they wear out, simultaneously the wheels will lose alignment, and you may find that the tires and steering wheels are shaking the vehicle when you drive the car. To evaluate the structural performance of tie rod, we need to consider the loads coming on the tie rod. From various theoretical studies and practical observations, it is observed that tie rod is under compressive loading condition and hence fails in buckling. Apart from this because of suspension force components fluctuating loads are also coming on the tie rod, due to random loads on a suspension of a vehicle.

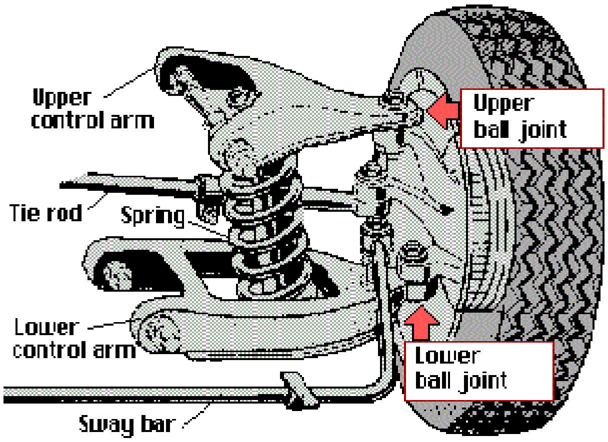

Fig 1: Connected Parts of Tie Rod

Parts Connected with Tie Rod

Figure 1 gives the idea about parts which are connected to the Tie rod.

- Sway Bar
- Coil Spring
- Arm -Lower Control
- Arm - Upper Control
- Arm - Knuckle

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1.3 Problem Definition

The existing tie rod is assembled using three different parts. The hollow, solid and ball joint which is quite complex design. Due to larger length of solid part, the design has become bulky and less efficient regarding load carrying capacity. There are chances of failure at the critical locations like notch, joints, fillets, etc. The tie rod is continuously under random loading there can be more chances of developing the cracks at the critical areas and chances of failure. The manufacturing process of existing design is critical and time-consuming. Hence, it is necessary to make the design simple and cost effective such that it gives overall effectiveness in terms of weight, cost, and load carrying capacity and easy in manufacturing process. The main task of this study is to reduce tie rod weight without failure in strength. Observe the deformation and stresses in the Tie rod. Set up the benchmark for the proposed design. Try to evaluate the possibility of different material combinations for optimized design. Target is to obtain the design such that critical buckling loads will remain same with a reduced weight of tie rod. The stress targets also need to be achieved. Pre-processing will be carried out using FEM software known as ANSYS. The results will be compared with practical and theoretical results. From the variables optimized tie rod will be selected and evaluated.

Objectives

- Transient Dynamic Analysis of Tie Rod.
- Weight Optimization of Tie Rod

II. STEERING SYSTEM AND TIE ROD

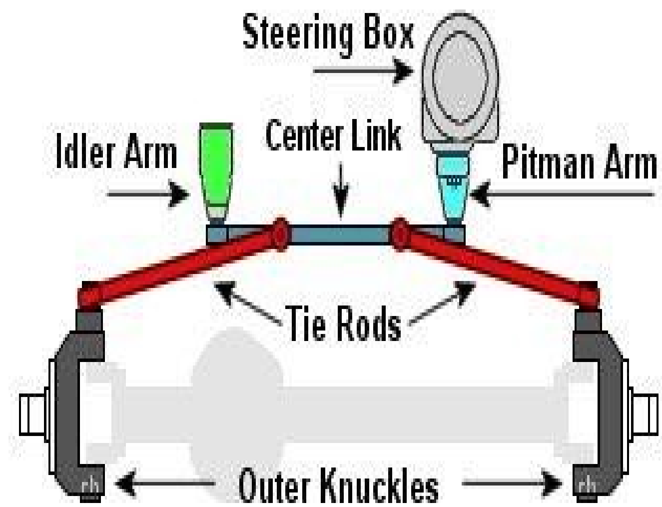

Fig 2.1: Components of Steering System

The Job of the Steering System:

A steering system is a group of parts which transmits the movement of the steering wheel to vehicle wheels. The primary purpose of the steering system is to allow the driver to guide the vehicle on the road.

When a vehicle is moving straight ahead, the steering system must keep it from wandering without requiring the driver to make steering corrections constantly.

The steering system will also allow the driver to get some road feel (feedback through the steering wheel about road surface conditions). For maximum tire life, the steering system should maintain the proper balance between the tires, both during turns and straight-ahead driving. Steering system should be designed such that the driver should be able to turn the vehicle with little effort, but not so easily that it is hard to control.

Common Steering System Parts:

All steering systems contain several common parts. Every steering system, of any type, will have steering wheel, steering shaft and column, flexible coupler, universal joints, steering arms, and ball sockets.

Types of Steering Systems:

Two main types of steering systems are used on modern cars and light trucks: the rack-and-pinion system and the conventional, or parallelogram linkage, steering system. On automobiles, the conventional system was the only type used until the 1970s. It has been almost completely replaced by rack-and-pinion steering. Many light trucks continue to use the conventional system.

Tie Rods:

A tie rod assembly is attached to each end of the relay rod. The tie rod assembly consists of inner and outer tie rods that are usually connected through an adjusting sleeve.

III. MODELLING AND ANALYSIS OF EXITING TIE ROD

3.1 Solid Tie Rod:

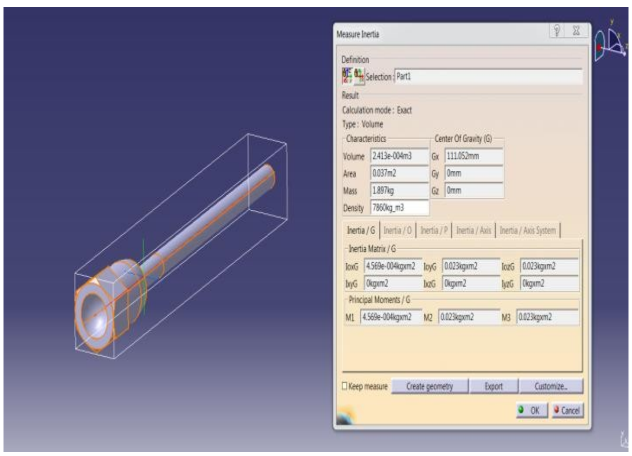

Fig 3.1: Tie Rod model and Weight (Solid tie rod)

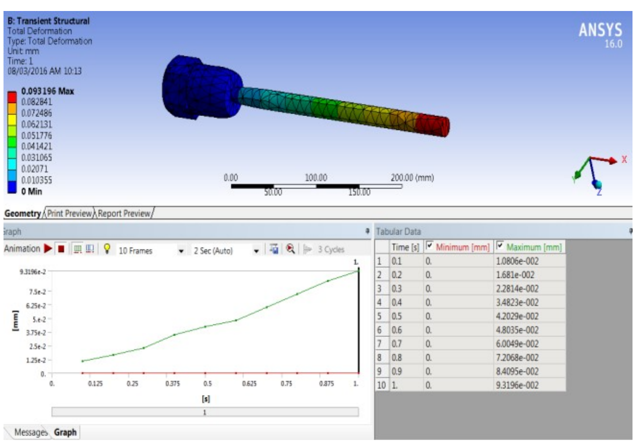

Fig 3.2: Result for Deformation

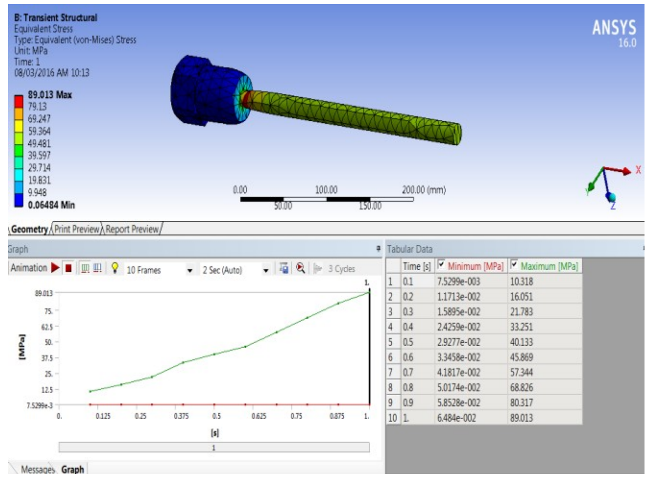

Fig 3.3: Result for Von-mises stress

IV. RESULTS BASED ON ANALYSIS CARRIED OUT FOR VARIOUS ID'S (HOLLOW SHAFT)

Sample Analysis for ID 11.4 mm:

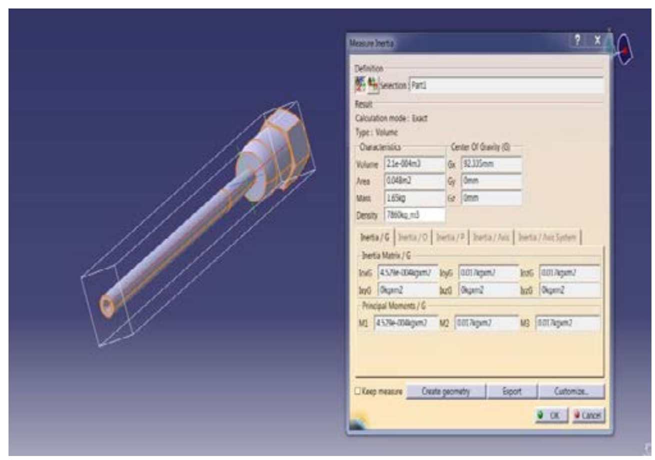

Fig 4.1: Cad model and Weight of Tie Rod (ID-11.4 mm)

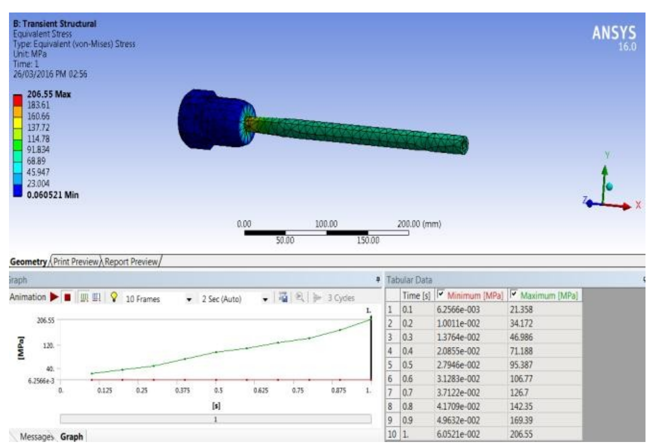

Fig 4.2: Stress in Tie Rod

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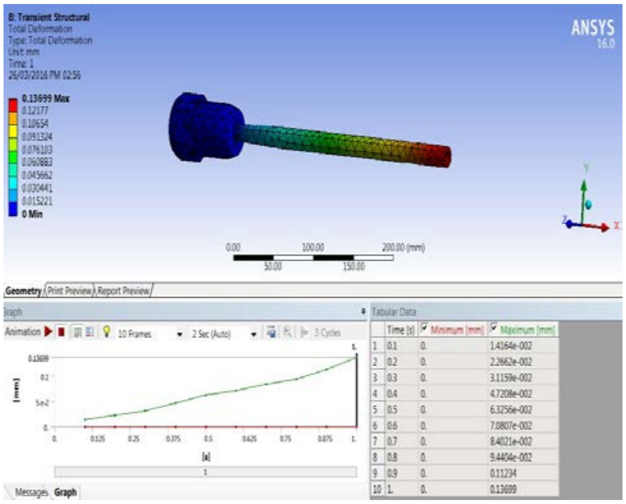

V. MATERIAL ANALYSIS RESULTS

Table 5.1: Results of Material Analysis

Fig 4.3: Deflection in Tie Rod Allowable Stress = Yield / FOS

= 405/2.0

= 202.5 MPa

Similarly, analysis is done for various ID's, and results are given in below table 4.1:

TRIAL	ID (mm)	Thick-ness (mm)	Stress (MPa)	Deflection (mm)	Weight (Kg)
0	**Solid**	**--**	**89.013**	**0.093196**	**1.897**
1	9.0	5.0	135.75	0.11018	1.743
2	9.50	4.75	143.15	0.11613	1.726
3	10.0	4.50	155.27	0.12064	1.707
4	10.50	4.25	169.89	0.12583	1.688
5	11.0	4.0	192.58	0.13194	1.667
6	11.4	3.8	206.55	0.13699	1.65
7	12.0	3.5	248.07	0.14871	1.624

From above results, we can see that with ID 11.0mm the stresses generated are within allowable and hence it is suggested for further work.

From the above result, it can be seen that for weight condition, Aluminum gives us better result without failure; hence, it can be used for an alternative to existing material. The cost of material is less compare to Steel and Cast Iron.

VI. CONCLUSION

- Tie rod plays an important role in the steering system and should be carefully selected.
- Transient analysis results for selected hollow Tie Rod are showing less weight compare to Solid tie rod without failure.
- Hollow Tie rod with ID 11.0mm is selected for optimization purpose.
- Overall (Compare to existing model with a solid steel rod) change in weight is 13.80 % for Steel- hollow tie rod.

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REFERENCES

[1] M. Amabili, "Estimation of tensile force in tie- rods using a frequency-based identification method" at Elsevier, Journal of Sound and Vibration 329 (2010) 2057–2067.

[2] Manik A. Patil, "FEA of Tie Rod of Steering System of Car" at IJAIEM, Volume 2, Issue 5, May 2013, ISSN 2319 – 4847.

[3] A.H. Falah, "Failure investigation of a tie rod end of an automobile steering system" at Elsevier, Engineering Failure Analysis 14 (2007) 895–902.

[4] Wei Duan, "Failure analysis of threaded connections in large-scale steel tie rods" at Elsevier, Engineering Failure Analysis 18 (2011) 2008–2018.

[5] Soohyun Nam, "Development of the light weight carbon composite tie bar" at Elsevier, Composite Structures 134 (2015) 124–131.

[6] Malge Sangeeta, "Performance of the Structural Analysis of Ford Car Steering Rod" at IJRAT, Volume 2, Issue 2, February 2014, E-ISSN 2321-9637.

[7] H.R. Kim, "A study of the manufacturing of tie- rod ends with casting/forging process" at Elsevier, Journal of Materials Processing Technology 125– 126 (2002) 471–476.

[8] Nerio Tullini, "Bending tests to estimate the axial force in tie-rods" at Elsevier, Mechanics Research Communications 44 (2012) 57– 64.

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